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Enfoque neurodidáctico de la enseñanza de la física en la formación del Técnico Superior de Biofísica Médica

Neurodidactic approach to the teaching of physics in the training for medical biophysics higher technicians

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Palabras claves: Neurodidáctica, Enseñanza de la Física, Aprendizaje de la Física, Biofísica Médica, Técnico Superior de Biofísica Médica

Resumen

Introducción: Una de las alternativas para la enseñanza de la Física lo constituye la aplicación de los conocimientos y vías que se ofrecen desde la neurodidáctica. Esta disciplina científica se desarrolla a partir de las propias indagaciones y de otros campos de la ciencia. Sin embargo, existe un camino por recorrer en las investigaciones científicas que permitan establecer las bases epistemológicas, teóricas y metodológicas de esta disciplina, que, en el caso de la enseñanza y aprendizaje de la física, todavía son limitados. **Objetivo:** presentar una aproximación a un enfoque neurodidáctico de la enseñanza de la Física en el programa de formación de Técnico Superior de Biofísica Médica en la Universidad de Ciencias Médicas de Matanzas. **Metodología:** Se utilizó el método analítico-sintético para determinar los aspectos esenciales de los resultados científicos que se relacionan con el tema de investigación. La inducción-deducción favoreció determinar regularidades desde lo facto-perceptual y configurar los aspectos teóricos que se proponen. El hermenéutico-dialéctico se empleó para la interpretación de la información teórica y realizar un análisis crítico. **Resultados:** Se establecen los aspectos teóricos que fundamentan el enfoque neurodidáctico y los pasos que se deben tener en cuenta para aplicarlo en la enseñanza de la física. **Conclusión:** Los aportes de la Neurodidáctica favorecen a la comprensión del proceso de enseñanza-aprendizaje de la física y constituye un marco teórico que posibilita el diseño de tareas y actividades que permiten potenciar la atención y motivación hacia el aprendizaje. **Área de estudio general:** Ciencias de la Educación. **Área de estudio específica:** Didáctica de la Física. **Tipo de estudio:** Artículos original

Keywords: Neurodidactics, teaching of physics, learning of physics, medical biophysics, Medical Biophysics Higher Technicians

Abstract

Introduction: One of the alternatives for the teaching of physics is the application of knowledge and means which are offered from neurodidactics. This scientific discipline is developed from its own inquiries and from other fields of science. However, there is an arduous road to go in the scientific researches that allow the establishment of the epistemological, theoretical and methodological basis of this emerging discipline, which, particularly in the teaching and learning of physics, the studies are still limited. Objective: is to show an approximation to a neurodidactic approach to the teaching of physics in the short-cycle training program for Medical Biophysics Higher Technicians in the University of Medical Sciences of Matanzas. Methodology: The analytical-synthetic method was used to determine the essential aspects of the scientific results that are related to the research topic. Induction-deduction favored determining regularities from the facto-perceptual and configuring the theoretical aspects that are proposed. The hermeneutic-dialectical was used to interpret the theoretical information and carry out a critical analysis. Results: The theoretical aspects that underpin the neurodidactic approach and the steps that must be taken into account to apply it in the teaching of physics are established.Conclusion: The contributions of the neurodidactics favor the understanding of the teaching-learning process of physics and constitute a theoretical framework that enables the design of tasks and activities that enhance attention and motivation towards learning.

Introduction

In the 2019-2020 school year, the short-cycle training program for Senior Technician in Medical Biophysics begins at the University of Medical Sciences in Matanzas. Two of the subjects included in the curriculum for this specialty are: Applied Physics and Radiation Physics. These are taught in the first and second semesters respectively and are designed so that students acquire the physical knowledge necessary to understand physiological phenomena of the human body and the area of Radiology for diagnosis and treatment with radiation and the use of nuclear medicine.(Torres-Hernandez, Rojas-Rosales, Alvarez Gongora, & Suarez Ceijas, 2020).

In the pedagogical practice of teaching these Physics subjects, difficulties have been observed on the part of students in learning physical knowledge and in developing skills that allow them to solve problems. These limitations include: the conceptual analysis of various physical laws and principles, the identification of the physical conditions of the problems and their mathematical modeling through equations, the theoretical and practical significance of the results, the interpretation of the signs and symbols that are presented in the virtual simulations of physical phenomena that are used in technological resources to develop virtual experiments.

It is notable how students arrive at university from the previous educational level with theoretical deficiencies that are not favorable for the analysis of problematic situations in physics. On the other hand, they show little interest and motivation for the study of physics. This reality has repercussions on the design of teaching activities that teachers must carry out to teach classes that lead to overcoming this state in students.

In the opinion of the authors, research in physics teaching is not sufficient to address student interest, motivation and learning. This claim is based on the fact that this science does not study the way in which the brain learns, which is essential to establish ways to achieve the objectives of physics teaching.

One of the alternatives for teaching Physics is the application of the knowledge and paths offered by neurodidactics. This scientific discipline is developed from the inquiries themselves and from other fields of science. In this regard, Chávez and Chávez Baca (2020) pointed out: "Neurodidactics is enriched by the main contributions of psychology and pedagogy, as well as by recent studies of a live brain provided by new brain visualization technologies, with the aim of implementing efficient and innovative learning environments" (Chávez & Chávez Baca, 2020, p. 147)

In relation to neurodidactics, several researchers, such as: (Brockington, 2021), (Simon de Astudillo et, al, 2021), (Chávez & Chávez Baca, 2020), (Nivela-Cornejo, 2020), (Ocampo Eyzaguirre, 2020), (to name just a few) agree that it focuses on the optimization of the teaching-learning process based on theories of brain development.

In this field of neurodidactics, there are several results that are oriented towards new forms of teaching and that can be applied in Physics subjects, including those achieved by Ameneyro et al. (2017) in which they use knowledge of neuroscience, such as the mediation of the feeling of achievement and emotions in learning. Others such as Nivela-Cornejo (2020) provide a vision of the use of neuroscience to promote academic performance. Researchers (Pherez, Vargas, & Jerez, 2018) establish pedagogical strategies based on neurodidactics and neurolearning. These investigations are part of the studies related to the field of neuroeducation and in particular neurodidactics.

However, there is a long way to go in scientific research that allows us to establish the epistemological, theoretical and methodological bases of this emerging discipline, which, in the particular case of teaching and learning physics, studies are still limited. In this sense, Brockington (2021) points out that knowledge about the neural mechanisms that support the learning of physics is insufficient.

Another situation is that "this discipline is recent and learning methods based on its studies have not yet been developed and, as it is in its infancy, it is more theoretical than practical" (Paz Illescas et al., 2019, p. 219). In the opinion of the authors of this article, there is a need to increase research that allows the development of teaching strategies and methods that are based on scientific facts and the use of scientific methods to establish the theoretical foundations that allow providing knowledge to promote learning by students.

On the other hand, in many teaching and research institutions in the educational field, there is a lack of knowledge of the results of neurodidactics and resistance to change in the ways of practicing the profession, by not recognizing the neurophysiological bases of the cognitive functions that are present in learning. This situation has repercussions on the systematization of this scientific discipline and, in the opinion of the authors of this text, constitutes some of the reasons why its implementation in the teaching of physics in Cuba is still limited.

The objective of this article is to present an approach to a neurodidactic approach to the teaching of Physics in the short-cycle training program for Senior Technician in Medical Biophysics at the University of Medical Sciences of Matanzas.

Methodology

The analytical-synthetic method was used to determine the essential aspects of the scientific results that are related to the research topic and that are presented in the scientific literature that was consulted. In addition, to determine the theoretical basis of the neurodidactic approach to teaching Physics in the Higher Technician of Medical Biophysics. The induction-deduction favored determining regularities from the factual-perceptual and configuring the theoretical aspects that are proposed. The hermeneutic-dialectical method was used to interpret the theoretical information and perform a critical analysis.

Results

One of the central aspects of the neurodidactic approach is that teachers must know how the brain learns in order to raise awareness and design school activities that promote active and developmental learning. This factor constitutes a source of knowledge that allows us to understand how the different actions carried out by students individually, in pairs, in groups or with the teacher, using both face-to-face and distance learning methods with or without the use of technological resources, directly and indirectly influence student learning.

> These neuroeducational themes need to be incorporated into teacher training programs, which will facilitate teaching and learning to become innovative, creative, critical and purposeful processes (Gil, June 21, 2015). To achieve this goal, teachers need to know more about the organ responsible for learning (knowing how the brain works and learns) and reflect on all those aspects that

> influence the learning process in order to make the student an autonomous, independent and self-regulated being.(Pherez, Vargas, & Jerez, 2018, p. 150)

It constitutes a foundation of the historical-cultural approach of Vygotsky, which he referred to as indicated in (Mecacci L., 2008) cited by(Pérez-Puelles, 2021, p. 159)that "the formation of higher psychic functions depends initially on biological mechanisms, which determine psychological functions (...) the higher functions, by appropriating culture, exercise control over the biological mechanisms, integrating the lower functions."

The neurodidactic approach to teaching physics in the Higher Technician of Medical Biophysics focuses on knowledge of neurosciences and is analyzed from the teaching process, so that it acquires a didactic value. Thus, it starts from the value of interest, attention, memory and motivation as neuropsychological states to achieve an active learning performance of students with high levels of academic performance.

It is considered that, in the teaching of physics, the teacher must direct the actions towards the essential part of the knowledge system in each teaching activity and avoid presenting in class aspects of physical, mathematical or other sciences that distract the students' attention from the main thing and lead to what very often occurs, which is a lack of understanding in the analysis of phenomena, concepts, equations and in the procedures to solve physical problems. As pointed out by (Stevens and Bavelier, 2012) cited by (Valerio, Jaramillo, Caraza, & Rodríguez, 2016) "Within the attentional process, selective attention, that is, the cognitive function in charge of focusing and ignoring distraction, is necessary in the academic learning process" (p. 76). This criterion is supported by the studies of (Riccio, Rabinowitz, & Axelrod, 1994) that show the limitation of human beings to maintain attention at the same time to a certain number of things.

Therefore, in physics teaching, it is necessary to ensure that students' attention is maintained during the teaching activity, because it establishes the necessary neuropsychological basis that leads to achieving favorable academic performance. "Attention is responsible for carrying out the information selection process within the nervous system, being the fundamental element that articulates all cognitive processes, directing and selecting the information to be processed" (Valerio, Jaramillo, Caraza, & Rodríguez, 2016, p. 76).

A study that supports this position was published in 2016 by Valerio, (et. al.), in which research was conducted with university students and it was shown that the use of teaching strategies based on neurosciences enhanced attention, motivation and higher academic performances were achieved. One of the ways presented consisted of focusing the activity on the main aspects of learning and the use of teaching resources to maintain attention.

Another important aspect is the role that prior knowledge plays in learning, which constitutes the basis for the process of appropriation of new knowledge, "said link with previous knowledge is related to the interconnection between neurons called synapses, so teachers must create meaningful memories that are associated with what students already know" (Chávez & Chávez Baca, 2020, p. 147) Relevant results are highlighted without incurring repetitions of information.

In order to achieve a meaningful long-term memory in students when learning physics, the activities developed must focus on the aspects necessary to establish the bases of knowledge and the application of these in the social context in which they are used. To this end, the procedures for applying them and that are related to the solution of physical problems are explained.

In this dynamic, students must be encouraged to actively participate in the learning process of the knowledge they receive in physics classes. To do this, teaching tasks must be made a way to develop cognitive and technical skills as a way of enriching personal experience. In this regard, the experience that is manifested in the solution of physics problems or the analysis of a particular teaching task, takes on didactic value not only because it maintains interest, but because it favors the synapse between neurons, an issue on which there is a consensus in the scientific community and that it has been shown that "practice and experience increase learning processes, this strengthens changes in neural circuits" (Ocampo Eyzaguirre, 2020, p. 17) and contributes to strengthening the links that condition the memory necessary for learning.

Classes must be planned in a system according to the interrelation with the objectives and levels of depth of knowledge and skills that students must develop, but for this planning it is necessary to link the different resources that will be used in each activity, so that students use their sensory senses and all the real possibilities they have to learn.

Technological resources play an important role in the teaching and learning of physics. Their use favors the efficiency and effectiveness of teaching methods, “since they can promote collaborative work through virtual teaching environments, if the particularities of the students and the educational content are taken into account” (Chávez & Chávez Baca, 2020, p. 150).

> According to Ramírez (2015), the teacher must take on the role of information facilitator, and must be the one who seeks to design instruction with interesting and significant problems for the student's context. In addition, he or she must promote learning through communication based on multiple sensory modes, with the support of multimedia resources duly selected and aimed at a didactic objective, which contribute to simplifying information and helping learners

> develop useful skills for social and work life (Gamo, 2018). (Chávez & Chávez Baca, 2020, p. 151)

The findings of neuroscience on how motivation arises in the brain and how there is a link with external activity that plays a direct role in the way in which a person, in interaction with his or her social environment, develops skills and manages to learn are relevant for the teaching of physics in the training program for Higher Technician in Medical Biophysics. Therefore, the social nature of the teaching-learning process is manifested in accordance with the neurophysiological process that enables the development of personality and learning in particular.

On the other hand, the existence of a communicative reserve (Habermas, 1987) that guides behavior is considered, but enriched from a cultural perspective (Torres-Hernández, 2019). It is assumed that the culture of students and teachers is enriched and manifested in Physics classes through communication as a particular case of the social relationships that arise. It is in this process that neural structures are modified and several neurotransmitters are transmitted that produce motivation and responses to it at a biological level. This argument is supported by the consensus of the scientific community regarding the role that neurotransmitters have in generating emotions, motivation and attention, which are necessary for learning.

> Dopamine is a very important neurotransmitter for motivation, since, according to Montague, Dayan and Seknowski (1996) cited in Reeve (2010): "it generates pleasant feelings associated with reward", which would be understood as a desire or a positive emotion of the student before carrying out an activity in class. In similar terms, dopamine (Gamo, 2018): "is the tension that moves to action from the motor areas" (p. 4), causing adrenaline and noradrenaline to be released, these neurotransmitters being responsible for maintaining the attention of the pupils during the performance of an activity until compensation. (Chávez & Chávez Baca, 2020, p. 152)

In this process, the satisfaction of a need or the construction of new knowledge is manifested and serotonin is released, a neurotransmitter that produces a state of tranquility or serenity that favors reasoning. Consequently, in physics classes, the teacher becomes an advisor and a guide of the main aspects that the student must master and it is through a process of communication with tasks that generate cognitive activity in students in an environment in which it is pleasant to teach and learn; positive experiences are manifested that constitute factors that favor attention and motivation.

In this neurodidactic approach, some steps proposed by neurodidactics are assumed, in particular those presented by Paz Illescas et al. (2019), which are reordered, enriched and others are proposed from the position of the authors for the teaching of Physics. These are:

First step: spark interest

It is necessary to identify the students' interests regarding several aspects, including: the study of the career they are pursuing, expectations of professional development after graduation, learning science and in particular physics. This step is considered the first, contrary to Paz Illescas et al. (2019), because it is believed that, at these ages of the students of the Higher Technician of Medical Biophysics, which generally ranges between 17 and 20 years, interest can manifest itself according to these directions and does not mean that the preconditions exist to achieve adequate motivation.

It may happen that a student studies a subject because he or she is interested in passing it in order to continue his or her studies and graduate, and not because he or she is motivated to learn it in order to apply it in his or her professional performance or to understand the phenomena with which he or she interacts in everyday life. For this reason, his or her interests must be diagnosed and, based on these, actions designed to maintain that interest or promote it, particularly in terms of learning physics.

Second step: Generate emotion

Emotion is fundamental in the learning process, it enables students to be motivated, it encourages active participation in solving teaching tasks and it promotes long-term memory. Regarding this idea, there is consensus in the scientific community about the role that emotions have in learning. For example, neurodidactics has shown that, “Emotions are what activate our motivation, moving us to act in the search for pleasure” (Navarro, 2018, p. 47).

According to this position, it is considered that teachers, when beginning classes, must reveal the need to appropriate the knowledge that will be addressed during the teaching activity. As well as using physical demonstrations, they must introduce questions that lead to problems that must be answered with the active participation of the students.

Now, each of the questions, problems or physical demonstrations must be of interest to the students, either because their learning is significant for their future professional performance or as basic knowledge to learn other specific knowledge that is directly related to the work they will do in the exercise of the profession.

According to Paz Illescas et al. (2019), for students to be persistent, they must feel that they are integrating the content because the brain learns through associations. “New information enters our brain and it links it with the information that resides in the hippocampus. This can consolidate memories” (Paz Illescas et al., 2019, p. 224).

This involves selecting the content to be covered in each class or teaching activity, highlighting the essentials and the relationship between each of them and the previous ones and revealing the need for these to learn and develop skills with those they will receive at another time, as well as the role they have in their training.

Step four: Evaluation from the perspective of learning effort.

A fair assessment is the process in which the student shows his systematicity in the activities he develops in class or outside of it based on his interests, emotions and motivations to learn Physics. In which it must be taken into account how he constantly improves to reach cognitive independence and self-regulation.

This whole process implies that physics teachers pay attention to the advances in neuroscience and research in the field of neurodidactics in order to transform the traditional approach to teaching and design different ways to optimize the teaching-learning process and improve the academic performance of students.

Conclusions

- Contributions from Neuroscience and in particular from Neurodidactics favour an understanding of the teaching-learning process of physics and constitute a theoretical framework that enables the design of tasks and activities that enhance attention and motivation towards learning.
- It is necessary to delve deeper into neurodidactic research to design strategies that contribute to optimizing the teaching-learning process of physics in the short-cycle training program for senior technicians in Medical Biophysics.

Conflict of interest

The authors declare that there is no conflict of interest in relation to the submitted article.

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